

Available online at www.sciencedirect.com**ScienceDirect**

Procedia - Social and Behavioral Sciences 86 (2013) 211 – 216

Procedia
Social and Behavioral Sciences

V Congress of Russian Psychological Society

Resolving the Conflict between Two Implicitly Learned Regularities

Nadezda V. Moroshkina^a, Ivan I. Ivanchei^{a,*}^a*Department of Psychology, Saint-Petersburg State University, 7-9, Universitetskaya nab., Saint-Petersburg 199034, Russia*

Abstract

This study is dedicated to the investigation of interaction of conscious and unconscious processes in artificial grammar learning. The main problem: how the conflict between two implicitly learned regularities contained in stimuli influences classification of them. The results of the experiment suggest that subjects implicitly learned not only the rules of artificial grammar, but also the hidden hint (a small font lengthiness). In the case of contradiction between the rules of grammar and the hidden hint subjects switched their strategy of task performance to an analytical one, being unaware of this contradiction. It was manifested in reduction of “yes” answers and, as a consequence, in reduction of the level of “false alarms”. This result suggests that a collision with stimuli that provoke conflict between implicitly acquired knowledge enhances the conscious control over the task performance.

© 2013 The Authors. Published by Elsevier Ltd. Open access under [CC BY-NC-ND license](http://creativecommons.org/licenses/by-nc-nd/4.0/).
Selection and/or peer-review under responsibility of Russian Psychological Society

Keywords: Consciousness; Cognitive unconscious; Implicit knowledge; Explicit knowledge; Artificial grammar learning, Analytical strategy, Intuitive strategy, Yesrate

1. Introduction

Implicit learning is a widely known phenomenon in cognitive psychology: it is a process of unintentional knowledge acquisition without the ability to express it explicitly and verbalize it [1]. Firstly implicit learning was found in the task of artificial grammar learning (AGL) and then in a range of other tasks (see [2] for a review). Further experiments showed that in AGL subjects use both the implicit knowledge and the explicit recollection of

* Corresponding author. Tel.: +7-812-328-00-01; fax: +7-812-328-00-01.
E-mail address: i.ivanchei@psy.spbu.ru

grammatical strings or their fragments [3]. The important issue of today studies is how implicit and explicit knowledge interact with each other while subject makes a decision and which of them has a priority.

Reber suggested two system approach postulating the existence of two independent cognitive blocks: consciousness and evolutionary older cognitive unconscious [1]. According to Reber, unconscious processing goes independently of consciousness, in its base lay older brain structures and it is more resistant to different traumas and deceases. P. Lewicki and colleagues claimed that consciousness has in principle no access to the results of cognitive unconscious' work [4]. However, some data appeared indicating that the increasing conscious control can impair the implicit learning results [5], [6].

In Reber and Allen's AGL experiments [5] subjects performed the string classification worse when they were informed about the existence of the grammar rules on the learning phase. In other words, when the informed subjects started to perform an explicit search of the grammar rules, their learning efficiency decreased. Moreover, it appeared that the implicit learning effect wasn't always manifested in replication studies. Lewicki himself and a range of other researchers started to discuss such a factor of learning process as subject's strategy [7], [8].

On the other hand, free verbal reports have been questioned to be an adequate measure of awareness of the knowledge acquired in learning (e.g. see [9]). Some objective and subjective measures were suggested as alternative, including subjects' confidence ratings [10]. The use of the new awareness measures led to more a differentiated classification of subjective experience of people (e.g. [11]). Summarizing experimental results we can say that subjects can form the following levels (or types) of knowledge while learning:

- unconscious knowledge that affects behavior in the task while subject thinks that he or she gives random answers;
- implicit knowledge followed by increasing confidence (intuition or meta-knowledge), that is the subject is aware that he or she knows something but can't say what exactly;
- explicit knowledge that can be verbalized.

On the way from the first level of knowledge to the second one, perhaps the emotions and some somatic processes take place, that are signals to consciousness about the existence of some knowledge in the unconscious sphere [12]. But people do not always accept these signals, it can be manifested by switching the intuitive strategy of decision making to the analytical one [8].

So we can suppose that there are several processes presented while learning. With trial repetition cognitive unconscious stores the upcoming information about frequencies and co-occurrences of different stimuli and parts of them: in brief, it learns the regularities presented in the material. New stimuli are compared with the unconscious "expectations" and the result of this comparison is followed by an emotional signal intended for consciousness. At the same time consciousness learns to track these signals and to discriminate the states of unconscious forming second order knowledge. But how does the explicit knowledge appear if consciousness has no direct access to the content of the unconscious representations? The answer to this question was suggested by the concept of mechanism of awareness developed by V. Allakhverdov [13]. According to the principle of independent verification, getting emotional signals about the states of unconscious, consciousness starts to make hypotheses about the causes of these states and tests them driving ones behavior. When consciousness switches to sequential testing of explicit hypotheses it can impair task performance, if these hypotheses are false.

According to Allakhverdov's approach (that we share), consciousness is first of all needed when upcoming information is uncertain, contradictory or ambiguous. In that case, unconscious can't choose one of the possible alternatives, and there is someone needed who can make a decision, based on nonempirical information or, in a pinch, who can "flip a coin". If so, insertion of some contradictive stimuli into the task should increase subjects' conscious control over the task performance, that is they should switch to analytical strategy increasing the role of explicit knowledge in the decision making process. This assumption was tested in the experiment.

1. Experiment

1.1. Method

For the experimental investigation of the influence of contradiction in implicit learning on the level of conscious control over the task performance we used AGL paradigm.

1.1.1. Participants

One hundred and thirteen students (37 male, 76 female) participated the study. An age range is from 18 to 25 years ($M = 21$, $SD = 1.6$).

1.1.2. Apparatus and stimuli

Special computer program was created to present stimuli and record answers. The experiment was run on Pentium-compatible PCs. The display had a white background. Stimuli (strings of Latin letters) appeared in the center of the display. Font: Arial Black; font size: 36; letters' colour: green and blue. The Brooks and Vokey's grammar [14] was taken as a basis of our grammar. Stimuli were different because of in our experiment there were more groups of subjects.

1.1.3. Procedure

Subjects were asked to take part in experiment aimed to study memory. The experiment consisted of two phases: learning and test. On the learning phase subjects were sequentially presented with 32 strings in random order: 16 grammatical and 16 ungrammatical, for 4 seconds each. Half of the strings were colored blue, and another half – green. Subjects were instructed to memorize green strings and ignore blue.

On the test phase 32 new strings were sequentially presented in random order: 16 grammatical and 16 ungrammatical. All the strings were black. Before test phase subjects were informed that green strings on the learning phase were composed on the basis of complex set of rules (artificial grammar). Then they were told that they will be presented with new strings and they should classify strings as based on set of rules (grammatical) or random (ungrammatical). Each string was presented for 3 seconds and then disappeared. Subjects were asked to response by presenting arrow keys: "left" – if he or she decided that string was grammatical or "right" – if he or she decided that string was a random letter sample.

All subjects were divided in four randomized groups: two control (C1 and C2) and two experimental (E1 and E2). On the learning phase in E1 and E2 all grammatical strings were green and all ungrammatical – blue. In addition one implicit regularity was introduced: all grammatical strings were graphically stretched wide by 115%. On the test phase in E1 all grammatical strings were also stretched the same way, but in E2 the contradiction was created: half of grammatical and half of ungrammatical strings were stretched.

Two control groups were used to test the ability of subjects to learn implicitly two introduced regularities (artificial grammar and lengthiness). C1-subjects learned only grammar: on learning phase all green strings was grammatical, but in both learning and test phases grammaticality and lengthiness did not correlate. C2-subjects learned only lengthiness. On both phases grammaticality and lengthiness also did not correlate: on the learning phase stretched strings were green, and on the test phase correct answer was the choice of stretched strings.

After test phase each subject completed a questionnaire, in which he or she answered if he or she noticed the differences in lengthiness and whether it helped to perform a classification.

1.2. Results

1.2.1. Learning

Learning was analyzed in all groups by comparison of mean percent of correctly classified strings with control level (table 1).

Table 1. Classification performance in groups C1, E1 and E2 (learning of grammar)

Group	Mean (percent of correct answers)	SD
C1	60.45	10.35
E1	60.61	10.18
E2	61.77	10.16
C2 (control)	54.40	10.32

In AGL experiments there is usually control group, learning random stimuli. In present study we used C2-data to compute the control level. C2-participants learned only lengthiness, grammaticality was irrelevant, so we used the proportion of grammatical strings (54.4%) in the set of strings chosen by C2-participants as a control level for grammar learning assessment.

To compare percentage of correctly classified grammar strings we used one-sample t-test. All three groups (C1, E1, E2) correctly classified strings significantly more often than 54,4% (C1: $t = 4.018$; $p < 0.001$, E1: $t = 4.391$, $p < 0.001$; E2: $t = 4.952$, $p < 0.001$). We can conclude that subjects in these groups successfully learned to classify strings on the basis of artificial grammar with the rules of which they were generated. Subjects in groups C1, E1 and E2 classified strings with just about similar level of correctness. Classification efficiency did not differ significantly (ANOVA, $F = 0.211$, $p = 0.811$).

To assess learning in C2, which subjects learned only lengthiness on the learning phase, we computed the percentage of stretched strings, that had been chosen as grammatical on the test phase (C2-subjects had the same instruction: classify strings as grammatical or not). The control level was the percentage of stretched strings that had been chosen as grammatical in C1, where lengthiness was irrelevant. C2-subjects chosen stretched strings as grammatical in 55.21% of all cases, and it was significantly higher than control 47.23% ($t = 3.755$ $p < 0.001$). So, learning also occurred in C2: subjects learned to discriminate 115%-lengthiness and chose stretched strings on the test phase.

1.2.2. Participants' strategies

Signal detection theory was used to analyze strategic data. Classification process was taken as a detection of grammatical strings (stretched – for C2) in the case of noise (the absence of reliable knowledge about classification basis). For all the subjects “hits” (answer “grammatical” when string is in fact grammatical) and “false alarms” (answer “grammatical” when string is ungrammatical) were computed. In the signal detection theory there also exist the concept of “observer's criterion” which refers to subjective requirements for stimulus to be viewed as signal. In our case it is the percentage of “yes” answers, that is - classification strings as grammatical (yesrate). These parameters were calculated for three groups (table 2).

Table 2. Hits, false alarms and yesrate in C1, E1 and E2

Group	Hits	False alarms	Yesrate
C1	0.59	0.38	0.48
E1	0.61	0.40*	0.50*

E2	0.56	0.32*	0.45*
----	------	-------	-------

ANOVA was used for comparison of groups E1 and E2. There was no significant difference in a hit-level ($F = 1.551$, $p = 0.218$). But it was in false alarm level: it was higher in E2 ($F = 4.062$, $p < 0.05$). The yesrate was significantly higher in E1 ($F = 5.649$, $p < 0.05$).

1.2.3. Reaction times

The groups did not differ in average response time (ANOVA, $F = 0.634$, $p = 0.595$). No significant differences were found in RTs in hit ($F = 1.755$, $p = 0.755$) or false alarm trials ($F = 1.755$, $p = 0.160$).

We also analyzed the decrease of RTs from the beginning to the end of test phase. We ignored first 5 trials, considering the process of task adaptation (in the analysis of RTs it can be particularly important). Trials from 6 to 32 we divided in three equal stages of 9 trials. We compared the change of mean RT from first to third stage in different groups.

E2-subjects did not show significant differences in RTs on going from the first stage (2290 ms) to the third (2120 ms) ($F = 0.678$, $p = 0.508$). RT in C1 decreased from 2710 ms in the first stage to 2380 ms in the third stage at the level of trend ($F = 2.753$, $p = 0.064$). RT's dispersions differ significantly on three stages in E1 ($F = 4.799$, $p = 0.008$), so nonparametric Kruskal-Wallace test was used. According to this test, subjects' RTs decreased significantly from 2430 ms in the first stage to 1770 ms — in the third (chi-square = 25.455, $df = 2$, $p < 0.001$).

1.2.4. Interview

According to the after experiment interview the portion of the subjects noticed that some strings were stretched (28% in C1, 48% in C2, 31% in E1 and 22% in E2). C2 and E2 differed at the level of tendency: more of C2-subjects noticed that some strings were stretched (chi-square = 3.429, $p < 0.1$). There were no significant differences between the other groups. Nobody grasped the connection between strings' lengthiness and classification. So we conclude that the subjects perceived lengthiness, but assessed it as an irrelevant feature.

2. Discussion

There were learning of both hidden patterns laid out in the stimulus material: grammar (groups C1, E1 and E2) and lengthiness (in the group C2). Learning of grammar was equally effective in all three groups of subjects. The after experiment interview suggests that learning of these features was largely unconscious.

We proved our hypothesis about the impact of contradiction on decision making strategy in the task of string classification as grammatical or not: E2-subjects acted more carefully and used more stringent criterion of decision making than E1-subjects. It was demonstrated by a reducing proportion of “yes” answers and the stable RT in classification task in contrast to E1-subjects, who decreased RT from the beginning to the end of the phase. We interpret this data as a strategy change. The analytical strategy differs from the intuitive one (holistic) by the choice of decision basis. For the holistic strategy it is a general impression of the whole stimulus. These impressions usually include some subjective feelings: feeling of familiarity, feeling of warmth etc (e.g. “this string is grammatical, because I like it”). Analytical strategy is, in contrast, connected with the choice of clear, verbalized criteria, relying on which one can make unambiguous decision (e.g. “this string is grammatical because after M goes T”). In the lack of explicit knowledge, analytical strategy leads to the fact that the answers “yes” (“yes, this string is grammatical”) are very rarely given. The explicit criteria are conscious and can be modified in learning by intentional hypotheses generation and testing. These processes take time, so such decisions are usually slower than while using the holistic strategy.

There are various conditions that affect the choice of strategy. They can be either internal or external. For example, the increase of sequential stimuli presentation speed force subject to use the intuitive strategy [8]. On the other hand, the requirement to justify their decisions provokes subject to use the analytical strategy [6]. In our study we create the situation of internal conflict in the implicit knowledge system, suggesting that it is critical for the mechanism controlling the interaction of consciousness and cognitive unconscious in learning. The results of the experiment prove the suggested view. It is important to emphasize that the switch of E2-subjects to the analytical strategy allowed them to demonstrate the similar efficiency level as in E1 group. We suppose that changing decision making criterion, E2-subjects actually stopped to rely on the implicit hint (lengthiness), which ceased to be relevant.

This work is the first in a series of studies, which, in our opinion, can resolve some contradictions in the field of the implicit learning research. We are talking primarily about the discussion of the approaches that claim that implicit and explicit knowledge are either the result of work of two different cognitive blocks, or the result of application of different strategies. We suppose that decision making strategies can be viewed as different modes of interaction of two cognitive blocks.

Acknowledgments

The research was supported by grant from Russian Foundation for Basic Research (Grant № 12-06-00311).

References

- [1] Reber AS. *Implicit learning and tacit knowledge: An essay on the cognitive unconscious*. 1st ed. New York: Oxford University Press; 1993.
- [2] Cleeremans A, Destrebecqz A, Boyer M. Implicit learning: news from the front. *Trends Cogn Sci*. 1998;2(10):587–90.
- [3] Mathews RC. The forgetting algorithm: How fragmentary knowledge of exemplars can abstract knowledge. *J Exp Psychol Gen*. 1991;120(1):117–9.
- [4] Lewicki P, Hill T, Sasaki I. Self-perpetuating development of encoding biases. *J Exp Psychol Gen*. 1989;118(4):323–37.
- [5] Reber AS, Allen R. Analogic and abstraction strategies in synthetic grammar learning: A functionalist interpretation. *Cognition*. 1978;6(3):189–221.
- [6] Ponomarev JA. *Psychology of creativity*. 1st ed. Moscow: Nauka; 1976. (in Russian)
- [7] Lewicki P, Hill T, Czyzewska M. Hidden covariation detection: a fundamental and ubiquitous phenomenon. *J Exp Psychol Learn Mem Cogn*. 1997;23(1):221–8.
- [8] Whittlesea BW, Price JR. Implicit/explicit memory versus analytic/nonanalytic processing: rethinking the mere exposure effect. *Mem Cognit*. 2001;29(2):234–46.
- [9] Shanks DR, St. John M. Characteristics of dissociable human learning systems. *Behav Brain Sci*. 1994;17(03):367–95.
- [10] Dienes Z, Berry D. Implicit learning: Below the subjective threshold. *Psychon Bull Rev*. 1997;4(1):3–23.
- [11] Dienes Z, Scott R. Measuring unconscious knowledge: distinguishing structural knowledge and judgment knowledge. *Psychol Res*. 2005;69(5-6):338–51.
- [12] Bierman DJ, Destrebecqz A, Cleeremans A. Intuitive decision making in complex situations: somatic markers in an artificial grammar learning task. *Cogn Affect Behav Neurosci*. 2005;5(3):297–305.
- [13] Allakhverdov VM, Gershkovich VA. Does consciousness exist?--In what sense? *Integr Psychol Behav Sci*. 2010;44(4):340–7.
- [14] Brooks LR, Vokey JR. Abstract analogies and abstracted grammars: Comments on Reber (1989) and Mathews et al. (1989). *J Exp Psychol Gen*. 1991;120(3):316–23.